Yellowstone Science

A quarterly publication devoted to the natural and cultural sciences

Yellowstone Climate Change
Packrats & Paleontologists
Radio Tracking Ethics
Underwater Geyser

Volume 1 Number 1

Welcome to Yellowstone Science

For more than a century, Yellowstone National Park has been recognized as a superb "outdoor laboratory" for many kinds of scientific research. The laboratory gets busier every year.

Last year, Yellowstone hosted 308 research projects involving 73 universities and foundations, 12 federal agencies, 7 state agencies and 3 corporations. These projects ranged clear across the scientific disciplines: 71 in physical sciences, 68 in forest, range, and plant ecology, 59 in assorted wildlife topics (with another 17 on wolves and 13 on bears), 39 in aquatic studies, 29 in microbiology (Yellowstone's hot-water life forms are of world interest), and 12 more in assorted prehistoric, historical, sociological subjects.

With the launching of this periodical we hope to accomplish at least two things. First, we will provide those widely scattered investigators with an opportunity to communicate with each other; at its best, *Yellowstone Science* will be a forum and a clearinghouse for them, to discuss issues and needs, and to exchange ideas.

Second, we can give the public a previously unavailable look at all this exciting science. We know that isn't a simple goal. Some of this science involves the perennial hot topics that make so many headlines. Yellowstone's Chief of Research refers to Yellowstone's administration as "resource management in a goldfish bowl" because the public interest in the park is so intense. Yellowstone exists in an atmosphere of almost continuous controversy; wolves, fire, bears, geothermal energy, elk, ecosystem processes and management, and a host of other topics cycle through the public's attention on an almost predictable basis. But the research on those topics is only a small part the spectrum of science in Yellowstone.

Our primary goal is to explore the full breadth of the work being done in the park--to celebrate, through the eyes and ears and voices of the researchers themselves, the knowledge and wonder they so often find in this amazing place. At the same time, and with younger readers especially in mind, we'd like to show, through example, how science works: what its limitations and strengths are, and what it means to all of us who care about Yellowstone.

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On the cover: A woodcut by Thomas Moran, based on his 1871 visit to the park area, showing the first known image of an identifiable Yellowstone fire. The view is east from West Thumb Geyser Basin, with smoke rising from Pumice Point. Fire history research indicates this area did burn around 1867, plus or minus 3 years. Moran may have seen the fire (though no reports of the expedition mention it), or may have noticed the recent burn site and added smoke for dramatic effect (from *the Aldine* 6[4]:74, April 1873).

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Yellowstone Science is published quarterly, and submissions are welcome from all investigators conducting formal research in the Yellowstone area. Editorial correspondence and requests for information about how to receive this publication should be sent to the Editor, *Yellowstone Science*, Division of Research, Post Office Box 168, Yellowstone National Park, WY 82190.

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Global Climate Change in the Greater Yellowstone Ecosystem

How will we fare in the Greenhouse Century?

by William H. Romme and Monica G. Turner

Global climate change, due to human-caused atmospheric disturbances, would have far-reaching effects on the Greater Yellowstone Ecosystem (GYE). Potential changes in temperature and precipitation are not well understood, but our knowledge of past climates in the GYE provides us with examples of the climate variations and how they might affect life here.

During the most recent glacial period, 20,000 to 16,000 years ago, the upper timberline in this part of the Rocky Mountains apparently was 2,000 to 3,900 ft. (600 to 1,200 m.) lower than today, and most of the Yellowstone Plateau was glaciated. As global temperatures increased and glaciers retreated (14,000 to 13,000 years ago in the GYE), the upper timberline shifted upward, and coniferous forests became established. The early Holocene (10,000 to 4,000 years ago) was a period of maximum warmth in the Yellowstone region, but the climate became somewhat cooler and possibly wetter in mid-Holocene, so that the lower timberline in the eastern GYE moved downward 5,400 to 4,400 years ago.

Because of increases in carbon dioxide and other greenhouse gases, another episode of global climate change is expected in the coming century. Current computer simulations of global climate change project an average rise in global temperature ranging from 34 to 40°F (1.5 to 4.5°C).

Projected Climate Scenarios

There is considerable uncertainty about effects of climate change on the region. Rainfall may increase, decrease, or remain the same. In addition, increases in atmospheric carbon dioxide may have direct effects on vegetation. For example, the water-use efficiency of plants may increase along with increased carbon dioxide. Thus, the warmer temperatures and the rise in evapotranspiration (that is, the loss of water from the soil through evaporation and from plants through transpiration) would increase plant water stress unless compensated for by increased precipitation or enhanced water-use efficiency.

The fairy slipper, dependent on old-growth forest habitats, could be seriously affected if the climate grows warmer and drier. Renee Evanoff illustration.

We emphasize that these ecological changes are projections, not predictions. Our present understanding of the impending climate changes are still too rudimentary to permit confident predictions.

The Warm, Dry Scenario

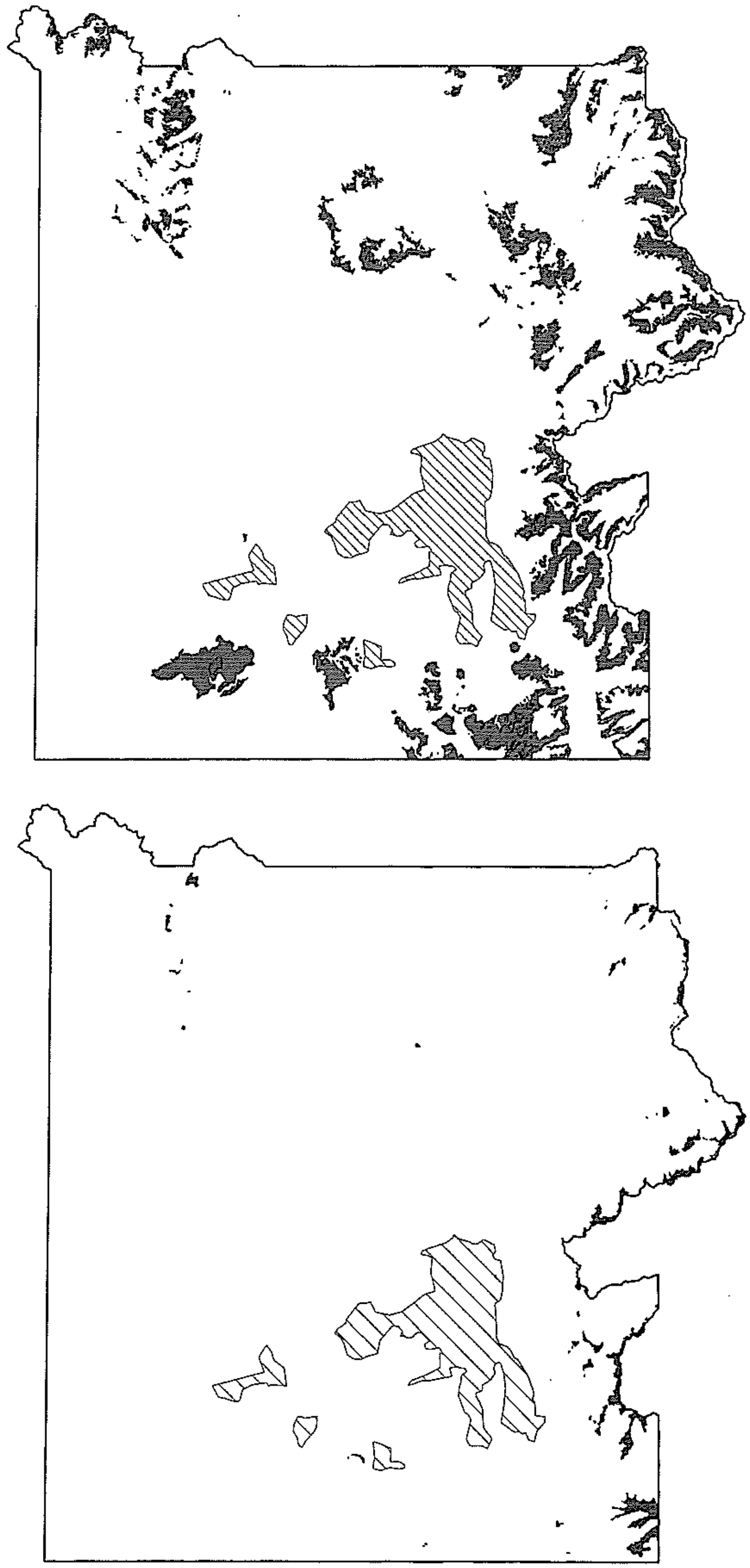
Higher summer temperatures would increase the growing season at high elevations. The upper timberline would probably shift to a higher elevation, an increase of 1,500 to 3,800 ft. (460 to 1,150 m.). For the projections in this paper, we use a conservative estimate of 1,500 ft. (460 m.). Upper timberline in Greater Yellowstone is now at around 9,500 ft. (2,900 m.), and would move to around 11,000 ft. (3,360 m.). The alpine zone could disappear completely in Yellowstone National Park, where the highest point, Eagle Peak, is only 11,286 ft. (3,440 m.). In the highest peaks of the Absaroka, Teton, and Wind River Ranges, an alpine zone would persist. Alpine species vulnerable to these changes include the arctic gentian, alpine chaenactis, rosy finches, and water pipit.

The lower timberline would also shift upward 1,500 ft (460 m) or more, reducing the total forested area because there is less land at higher elevations. This would in turn reduce the amount of high-elevation forest types. For example, whitebark pine forests occur in a zone from 8,500 to 9,500 ft. (2,600 to 2,900 m.), which occupies an area of about 617,750 acres (250,000 hectares) within Yellowstone National Park. If vegetation zones shifted upward by 1,500 ft. (460 m.), then whitebark pine would be found from about 10,000 to 11,000 ft. (3,060 to 3,360 m.), with an area of only 66,700 acres (27,000 ha.). This is a 90 percent decrease in habitat for whitebark pine, an important food source for Clark's nutcrackers, red squirrels, and grizzly bears.

Douglas-fir, on the other hand, would be favored by the change. A 1,500-ft. (460 m.) upward shift would actually result in a larger potential range for this species in Yellowstone Park, because most of the park lies above 6,600 ft. (2,000 m.) and Douglas-fir occurs mostly between 6,200 and 7,200 ft. (1,900 and 2,200 m.). However, Douglas-fir would probably disappear from lower elevation areas elsewhere in Greater Yellowstone, so its regional abundance would remain the same or decrease.

The subalpine forest landscape of Greater Yellowstone contains numerous old-growth stands that exceed 200 years in age. If a warmer, drier climate leads to an increased frequency of severe stand-replacing fires, the landscape could be converted into one dominated by younger stands, as in the Canadian Rockies and subarctic. Habitat for old-growth species, including the northern twinflower, fairy slipper, pine marten, and goshawk, could become smaller in area and more fragmented.

With an upward shift in the lower timberline, the area of low-elevation nonforest vegetation would increase. Animals characteristic of treeless landscapes, such as pronghorn and badger, might become more numerous. Sagebrush-grasslands, dominated by big



Whither the whitebark?

The upper map shows current distribution of whitebark pine, a key food source for grizzly bears, in Yellowstone Park. The lower map shows remaining available habitat under the warm, dry scenario described on pages 4 and 5. Maps courtesy of the Yellowstone Geographic Information System Laboratory, Yellowstone Park.

sagebrush, bluebunch wheatgrass, and Idaho fescue, probably would move to higher elevations. At the lowest elevations, sagebrush-grasslands could be replaced by semidesert vegetation, characterized by saltbush and greasewood.

Species will respond individually to the environmental changes because of differing physiological tolerances, resulting in altered success between competing species. Entire life communities could undergo major changes.

The total numbers of elk, bison, and other native ungulates are limited primarily by the availability of winter forage. Nonforested areas at low elevations provide the major winter habitat for these animals. Milder winters and a larger nonforest area at low elevations could mean higher populations of ungulates throughout Greater Yellowstone. Of particular significance would be the increased winter habitat within protected parks, which lie at relatively high elevations. However, the associated drier conditions also might depress plant production, and elevated atmospheric carbon dioxide could produce altered carbonnitrogen ratios in plant foliage, canceling out the habitat enhancements of milder winter weather.

The Intermediate Scenario

In the intermediate scenario, a large, compensating increase in water use efficiency in plants would accompany increased temperature, increased evapotranspiration, and reduced or unchanged precipitation. Length of the growing season would increase, upper timberline would move upward, the alpine zone would be reduced, and local extinction of some alpine species could occur.

On the other hand, the position of the lower timberline might not shift, because the effects of higher evapotranspiration would be compensated for by increased water use efficiency. Thus, the elevational range of Douglas-fir could expand, because its lower limits, which might not change, are set by drought stress.

With a higher upper timberline and no change in lower timberline, the total forest area would increase. However, the forests would probably shift to younger age classes, because the increase in water use efficiency could compensate for physiological drought stress, but would not reduce the occurrence of severe fires.

The area of nonforest communities at low elevations would not change in this scenario, but there could be dramatic changes in species composition, because plant species would not respond identically to the changes. The area of nonforested winter range also would not change in this scenario, but the range could be more accessible in milder winters. The fertilization effect of elevated carbon dioxide could increase forage production, but soil nutrient limitations and altered carbon-nitrogen ratios might limit this increase.

The Warm, Wet Scenario

In this, as in the previous scenarios, warmer temperatures probably would lead to an upward shift in upper timberline, and some alpine extinctions. The

One of Yellowstone Park's foremost attractions is its large herds of ungulates. Elk populations, already controversial in park management dialogues, could increase under some future climate scenarios.

range of whitebark pine would shift upward and occupy a smaller area. With increased precipitation, however, even the remaining subalpine environment could become unsuitable for this species because of increased competition with other species.

Whitebark pine is near the southern limit of its distribution in Greater Yellowstone. A climatic shift to wetter summers could result in further reduction or even local extinctions of whitebark pine in Greater Yellowstone. Drought stress at low elevations would be eased, and the lower timberline could shift to a lower elevation. The range of Douglas-fir could expand both upward and downward in this scenario, increasing forest area. Wetter conditions, especially in summer, could lead to a decrease in fire frequency and severity and a shift in forest age-class distribution to older age classes. Thus old-growth habitat would increase.

The nonforest area at low elevations would be reduced if the lower treeline moved downslope. Semi-desert species and communities could disappear entirely from YNP. Less nonforested area means less winter range and fewer ungulates. Ungulates are adaptable, however, and would probably use forest habitats more, and milder winter temperatures increases in forage production might increase ungulate carrying capacity.

Warmer temperatures, longer growing seasons, increased precipitation, and elevated carbon dioxide could increase primary vegetation productivity, but other limiting factors, such as soil nutrients, might prevent or limit such increases. Because individual plant species will each respond differently to all of the changes, some dramatic changes in community composition could occur throughout the vegetation of the GYE.

How Will It Happen?

The three climate scenarios share some similarities. The upper treeline in the GYE is likely to move toward higher elevations in response to increased temperatures, and the distribution of Douglas-fir is likely to expand. The alpine and whitebark pine zones would probably decrease in extent and become more fragmented, causing some alpine species and communities to become locally extinct within YNP and possibly the GYE during the next few centuries. However, the total number of species within YNP and the GYE actually may change little. Semi-desert vegetation, which is currently rare and restricted to specialized habitats, may expand in lower-elevation portions of the GYE, especially under the warm, dry scenario.

The simplistic prospect of a smooth northerly and upward migration of plant species and communities is complicated by individual species responses and by the rate at which climate change may occur. By the time a slow-growing tree reaches reproductive age, the environment may no longer be suitable for seedling survival. Probably the species that will most quickly track the moving thermal zones are those with short, rapid life histories, e.g., introduced weeds, or species with a broad distribution such as lodgepole pine. The species that will respond least effectively are the long-lived species that reproduce late or irregularly and those with already limited, fragmented distributions, such as whitebark pine and alpine species. Competitive interactions between species also would be complicated as new species from lower elevational zones become established in the higher zones where adults of the formerly dominant species still exist.

Mature individuals of many long-lived species may persist in their present locations for as much as decades, even centuries, after the climate becomes unsuitable for survival of their offspring. Plant communities might appear stable for a long time, but after a disturbance (such as fire, insect outbreak, or windstorm) the mature forest community could be replaced by a completely different suite of species.

Research and Monitoring Needs

It is important to design long-term measurements creatively so that they are sensitive to early indications of ecological change. For example, species or individuals that are near the limits of their range of tolerance are likely to respond more rapidly than those that are well within their physiological range. Upper and lower timberlines can respond quickly even to climate changes of the magnitude observed in the last 100 to 500 years, and should be high priority sites for research and monitoring.

Another early indicator of global climate change may be alterations in the frequency and severity of natural disturbances. Given the importance of fire in the GYE, particular emphasis should continue to be placed on increasing our ability to predict the occurrence and effects of fire. Post-fire succession should be monitored following the 1988 fires and after future fires, especially in areas near upper and lower timberline.

The grasses and shrubs are likely to show more rapid changes in productivity and composition in response to climate than the subalpine forests. The grasslands also are influenced by native ungulates, so research into vegetation-climate-herbivore interactions should continue.

Although the inevitability of global climate change is not assured, the potential implications are of sufficient magnitude that it would be foolish to ignore them. The conservation of biological diversity in extensive natural areas such as the Greater Yellowstone Ecosystem will become increasingly difficult as the broad-scale constraints on the biota undergo changes that are more rapid than those experienced in the past. Explorations of potential scenarios can provide useful tools to increase our understanding of the ecological dynamics of climate change, and can stimulate discussion about the strategies appropriate for maintaining biological diversity in the face of environmental change.

William Romme, of Fort Lewis College, Durango, Colorado, and Monica Turner, of the Environmental Sciences Division, Oak Ridge National Laboratory, Tennessee, are both active in ecosystem-scale studies in Greater Yellowstone. *This article is an abridged version of a longer paper that appeared in* Conservation Biology *in September, 1991.*

Bugged Bears & Collared Cougars

The rewards and challenges of wildlife radiotelemetry

by Mark Johnson

As the sun sets beyond the meadow, a man in Bermuda shorts, with camera in hand, watches a pronghorn move slowly toward him. As if unaware of its admirer, the pronghorn continues to graze, briefly stepping onto a tall mound. The scene appears perfect, with sunset colors, a mountainous background, and a wonderful pose by the graceful animal. But then the late-afternoon sun highlights something else, something less natural: the trim, artificial circle of a radio collar riding low on the pronghorn's neck. The photographer no longer has the scenic picture he was hoping for.

For decades, marked, tagged, and collared animals have been a part of the Yellowstone Park setting, and for just as long, people have discussed and debated the effects of these scientific attachments on animals and on our appreciation of those animals. For some people, tags, collars, and other gear show positive efforts to understand and manage the animals. Others wonder if these manipulations are necessary, humane, or even appropriate in a national park.

Today, with growing concerns over humane treatment of animals, and rapidly changing public attitudes about the aesthetic and even spiritual place of wild animals in human society, a marked animal generates questions that address the changing views towards wildlife, the accuracies of our science, and the goals of our national parks.

What is radiotelemetry?

Radiotelemetry--attaching a transmitter to an animal to study it remotely--is an important technique for gathering information from long distances. Usually such studies focus on the animal's location, but telemetry can also determine the animal's temperature, heart rate, body position (to determine if it is feeding or resting), and even if the animal is still alive. A telemetry unit consists of a transmitter, battery, antenna, and some form of harness or other attachment to the animal. The package is designed to conform to the shape and behavior of the animal. Each animal in the study has its own signal frequency, so any one of them can be identified by a biologist with a receiver.

Originally, telemetry units were bulky and heavy, and were placed only on large animals, such as elk or bears. Early researchers were extremely resourceful, building "home-made" collars strong enough to endure the elements (including the attentions of ani-

Interagency Grizzly Bear Study Team member attaching radio collar to an adult grizzly bear.

mals, as in the case of a collared sow whose cubs might take to chewing on the collar). In Yellowstone, for example, some grizzly bear collars used during the pioneering Craighead research project (1959-1970) were made of metal strapping covered with garden hose, and the transmitter unit was encased in fiberglass with liberal windings of electrical tape. Later, heavy molded plastic encased the telemetry units, and a strong fabric strap held the unit in place.

Today, advanced technology has significantly improved telemetry with miniaturized electronic components. Biologists now radio track animals as small as bats, toads, and fish (the signal even works in water). Small telemetry units attach to animals with collars, legbands, and backpacks, and sterile transmitters are surgically implanted in the abdominal cavities of several species.

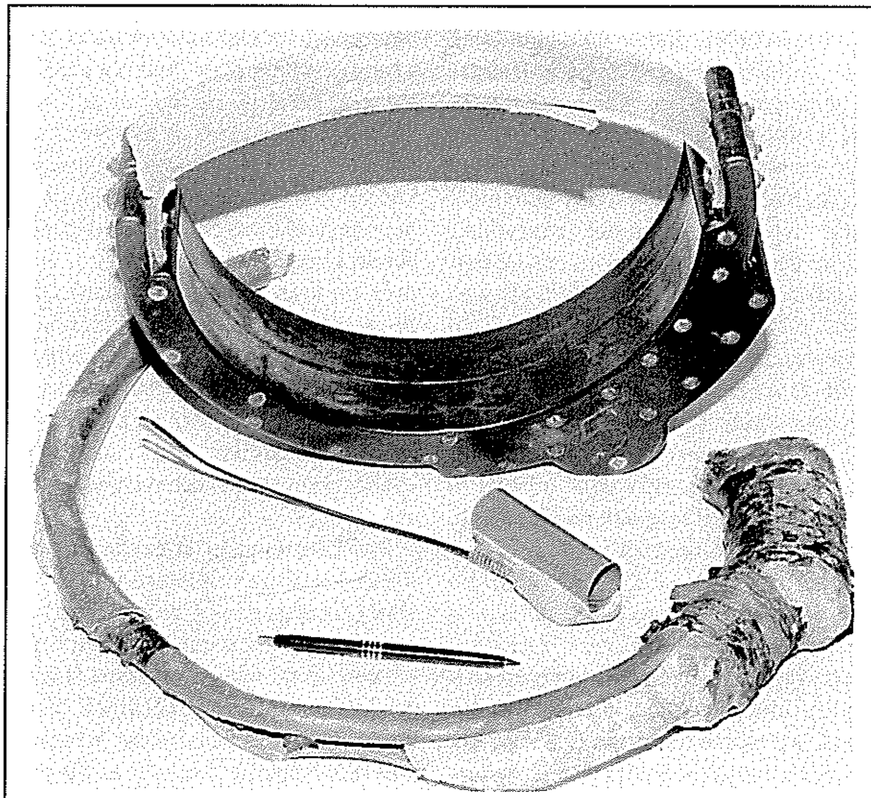
Some animals, because of their shape or extreme range, present unusual challenges. In 1984, greater sandhill cranes summering in Yellowstone National Park were studied using telemetry attached by legbands. Solar panels in the telemetry unit provided power for as long as 4 years. Small rivets attaching transmitter units to legbands usually corroded after the unit quit functioning, so the transmitter would fall off. With these advanced telemetry units, biologists learned that cranes summering in Yellowstone National Park migrated through the San Luis Valley, Colorado in spring and fall and wintered in the Rio Grande Valley in New Mexico.

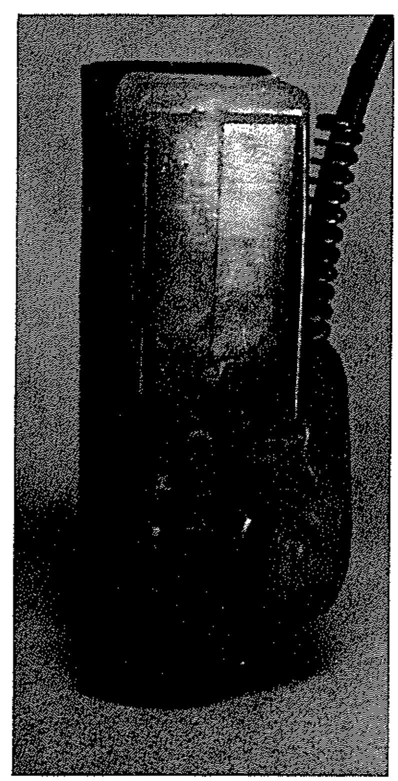
Amphibians and reptiles are especially difficult to find and study, though worldwide concern over declining amphibian populations makes such studies extremely important. A herpetologist recently described the classic capture-recapture technique used with snakes as the "mark, release, and never see them again" technique. Biologists at Idaho State University plan to study spotted frogs and western toads--two Greater Yellowstone species experiencing declines in other areas. They will place "backpacks" with 1.9-gram transmitter units onto 40-gram animals (about 3 inches in body length). At this writing, prototype backpack units are being developed under controlled conditions to ensure there is limited impact on the animal.

When is telemetry justified?

The reasons for telemetry are surprisingly diverse. There are practical management reasons, such as the need for collecting data on bears to assist with management of human/bear conflicts. Most people would agree that human

Below left: a collection of wildlife radiotransmitters, including (in front) a grizzly bear collar used during the 1960s in Yellowstone (garden hose over metal strapping, with the transmitter encased in fiberglass) a slightly less vintage bear collar with canvas strap attached to a transmitter encased in heavy plastic, a legband transmitter for sandhill cranes (attached to the upper leg, so the antenna will extend downward parallel to the leg), and a abdominal radiotelemetry implant for 8-week-old coyote pups.
Below: a closer view of the legband transmitter. The solar panels (visible on the top half of the unit) replace batteries as a power source.



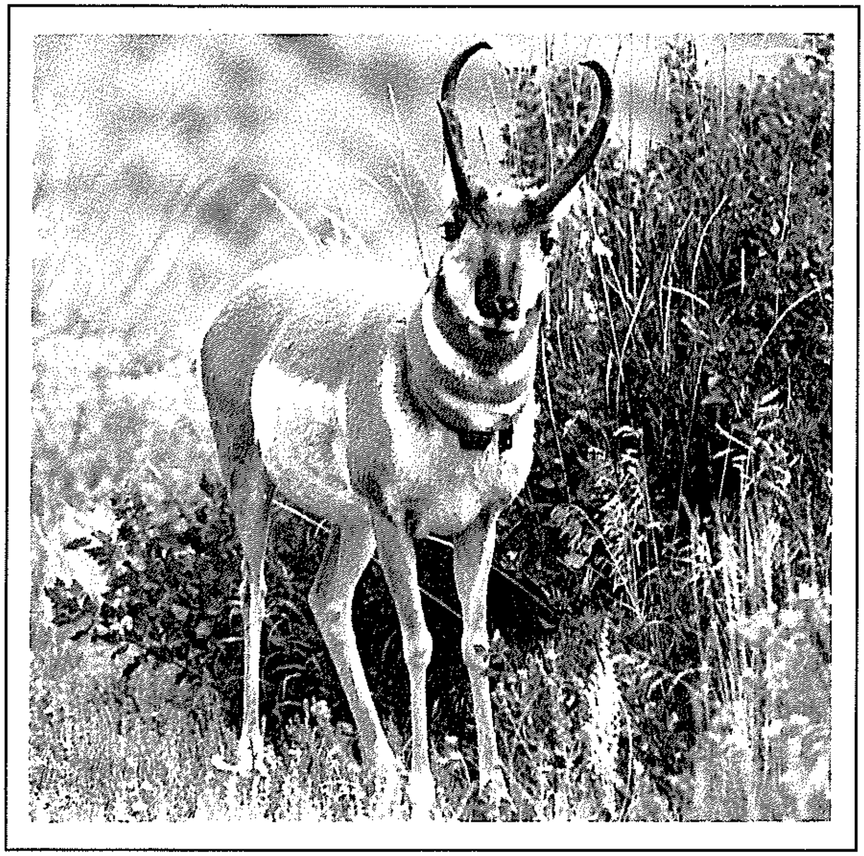


safety is a very high priority of park managers, and active monitoring of seasonal bear movements can alert managers to the movements of the animals into possible conflict situations.

Political and legal reasons can also dictate the need for telemetry studies, as when political processes for wilderness designation depend heavily on scientific information about endangered and threatened species. Federal agencies are required by law to determine the condition of endangered wildlife populations, and such information can often only be obtained through radiotelemetry. In Yellowstone, the possibility of reintroduction of wolves required managers to learn the condition of many other species in order to project potential influences of wolves, both on other predators and on potential prey. These legal imperatives can leave managers with little choice but to employ radiotelemetry.

In most cases, though, the use of radiotelemetry comes down to striking a balance between the impacts on the animals and the value of the information that is gathered. Stu Coleman, Resource Management Specialist, Yellowstone National Park, says that "if information gained is worth more than the disturbance to the individual and species studied, then the telemetry study is worth doing."

Yellowstone's famous grizzly bears are a good example of this. Radiotelemetry has been used for more than 30 years to monitor population trends, movement patterns, food habits, and habitat use. During 1990, the IGBST monitored a total of 35 grizzly bears for ecological studies. Telemetry studies with these 35 bears have played a major role in the preservation of this threatened species and their habitat. And as research continues, new pressures on the bears and their habitat expand the need to learn more.



Does telemetry affect the animal?

When telemetry *is* justified and animals *are* handled and marked, it is important, both ethically and scientifically, to affect the animal as little as possible. Few biologists would deny that telemetry affects the animals they are studying, but they must always ask how these effects can be determined and minimized.

Kerry Murphy of the Wildlife Research Institute studies mountain lions in Yellowstone's Northern Range. Unlike most studies, which collar only to a portion of the population, Kerry strives to radio collar all mountain lions in his study area. He describes an ethical scientist as "one who does everything from the very beginning to ensure that study techniques do not affect the animal. This is in theory, though. In reality, effects will likely occur, so when effects are seen, a good researcher will change study methods."

Kerry recognizes that studying lions might influence individual animals in several ways: 1) capture and handling, 2) wearing of the radio collar, and 3) disturbing the animal while radio tracking. Kerry's research statistics--72 radio collared lions over 152 captures with no capture-related mortalities--is not achieved without a conscientious and introspective attitude. From observing animal behavior during capture to monitoring of the captured animal's vital signs, every attention is paid to its condition until it is safely released again.

Determining the impact of telemetry on the animal after it is released is extremely difficult. Biologists commonly assume that some impacts, such as any resulting from wearing a collar, are negligible if the animal performs basic activities such as establishing a territory, mating, and producing young. Such rationale is weak, because these may be crude measures ignoring more subtle impacts. In many cases, however, these are the only criteria that can be used, because it is impossible to know if the animal is really behaving as it would if it didn't have the collar on. Uncollared animals cannot be followed as well as collared ones, and so we cannot compare the behavior of the two groups.

Tracking may also affect the animals. Telemetry allows biologists to approach study animals at will, so personnel can potentially stress the animal, and change its normal movement patterns and behavior, reducing the accuracy of the study. As part of his study, Kerry has followed specific lions for as much as 55 consecutive days to determine the

A spotted frog wearing a prototype .07 ounces (2 grams) backpack radiotransmitter. This frog weighs only .9 oz. (26 g.), and is just "modelling" the transmitter for photographic purposes; frogs that will wear this unit in field research situations will more typically weigh 1.4 oz. (40 g.). The transmitter has a range of about 325 yards (300 m.). The backpack is made from panty hose fabric. Photo courtesy of Charles Peterson, Curator of Herpetology, Idaho Museum of Natural History.

lion's frequency of predation. To reduce his effects on the lions, he uses the telemetry to avoid disturbing the animal. Because Kerry and his team usually know the location of the lion, they are able to wait until they are sure that it has left the area. For example, lion kills are not investigated until the lion has completely left the area of the carcass.

One way to reduce the long-term effects of collaring animals is the use of "break-away" collars that deteriorate and fall off after a certain period of use. In a study where it is difficult to recapture the animal, such a collar reduces the impacts of research.

Is telemetry humane?

The public's increased concern for animal welfare has increased the self-awareness of wildlife personnel and agencies. More than ever, wildlife biologists are addressing the animal's well-being as the highest priority of telemetry programs. Dr. Robert Crabtree, of Montana State University, currently oversees coyote studies in the Lamar Valley and the Blacktail Plateau in Yellowstone National Park. Yellowstone coyotes are one of the few relatively undisturbed and unexploited populations in temperate North America. In his study, Dr. Crabtree uses telemetry to study the movements, behavior, and mortality causes of coyote pups. Little is known about these young animals, partly because they grow too fast to be radio collared.

To help overcome this obstacle, I recently assisted Bob in his research by surgically implanting small, sterile transmitters into the abdominal cavities of coyote pups. The coyote biologists recognized we were affecting pups through capture, handling, and surgery, so we all took every precaution to minimize physical and psychological stresses. All field personnel spoke in soft whispers. Pups stayed in cool, dark cloth bags, and were handled as little as possible. Once under anesthesia, temperature, pulse, and respirations were monitored every 10-15 minutes.

Surgeries were conducted on the site of the capture, in a tent much like a small field clinic. And as soon as the pups recovered, they were quickly returned to their quiet den. After each session, we reviewed the day's events, seeking ways to refine and improve our work.

While those of us in wildlife science and management are constantly improving the capabilities of radiotelemetry and reducing the impact on wildlife, the *real* ultimate goal may be never to handle wildlife at all. But handling wildlife cannot yet be avoided, and so when telemetry is needed, the highest priority should be the well-being of the animal.

What do park visitors think of it all?

During a study of white-tailed deer in Cades Cove of Great Smokies Mountain National Park, visitors were surveyed to determine their attitudes towards radio collared deer. The survey revealed that park employees were more bothered by the adornments on the animals than was the general public. In fact, given time educating the general public, the public was very supportive.

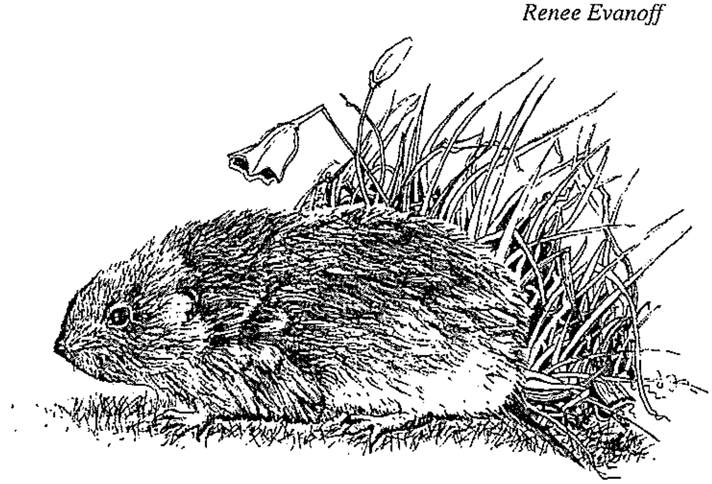
Still, the goals and policies of the National Park Service are to keep animals in as natural a state as possible. The University of Wisconsin-Madison is currently conducting research to provide alternatives to visible radio collars. Bob Garrett and P. J. White are studying the highly visible elk in the Firehole/ Madison area of western Yellowstone. Their principle objectives are to investigate links between habitat, diet, physiology, and population dynamics. Bob and P.J. are testing abdominal implants in 6 of 25 radio collared elk to see if implants can be a reliable and less visibly distracting alternative to collars.

It is remarkable how technology has allowed us to follow and study animals from a distance, and to locate them whenever we wish. The diversity of telemetry has almost matched the diversity of wild animals in the Greater Yellowstone Area. Although technology will continue providing us with new techniques and approaches for studying wildlife, there must always be an underlying concern about what we are doing and why we are doing it. Radio tracking of wildlife can never be taken lightly, no matter how far technology advances. It is important for researchers and lay persons alike to ensure that we are conscious of our reasons, conscientious in our actions, and, most of all, respectful of the wild animals that mean so much to us.

Mark Johnson is a wildlife veterinarian with a wide experience at wildlife handling and radiotelemetry. He currently works for the Research Division in Yellowstone Park.

Yellowstone Science Interview:
Elizabeth Barnosky

Renee Evanoff



Confidence in the Past

The practice and potential of wildlife paleoecology in Yellowstone

Until recently, relatively little was known about life in Yellowstone from the end of the last ice age until the arrival of Europeans in the New World. Several studies have been underway in recent years to change that, including Elizabeth Barnosky's paleoecological excavations on Yellowstone's Northern Range. Her first site, now known as Lamar Cave, resulted in an M.S. thesis at Northern Arizona University in 1990. Since then she has continued that work and has added a second site in the Soda Butte drainage. These are the first wildlife-oriented paleoecological studies in the park, and have opened a fascinating window on the region's prehistory. This interview with Liz was conducted in July of 1991, just as she was finishing her excavation of the Soda Butte site. Ed.

Yellowstone Science Caves have a magic that attracts even the layman, but not just any cave will do for your purposes. What kind of things are you looking for when you're trying to find a site that's going to be useful?

Elizabeth Barnosky Deposition and preservation are the two keys. You need a site that has depth, that doesn't just have rock right under it, and that's in a spot that could keep it safe. It's possible to just walk out anywhere and start digging and find some sort of obsidian flake, for example, or some other archeological remains. But a good, useful site is not likely to happen just anywhere, because most places have constant turnover of the top surface of the soil, and you're looking for a place where whatever gets buried stays that way.

Near streams, you look for alluvial deposits, where there have been floods and then the stream has moved and just left its bed covering whatever it covered. Abandoned meanders in a river are perfect places to look. Preservation of animal remains is affected by several factors after they're buried, too. There's soil pH involved, and you don't want a site that's been wet and dry a lot. Now that I know what to look for, I realize how lucky I was; the Lamar Cave turned out to be the perfect little storage unit.

YS But what makes all this possible, all this perfect storage of animal remains, is in fact another animal. I suspect that very few people realize how dependent studies of this sort are on packrats. How do packrats do it? What do they collect? What form do they find it in?

EB Really, I don't know of another way to get this information other than packrats. They are so good at collecting, but there's a lot about packrats that we don't know. The studies that have been done in other parts of the country say that they collect material from within fifty meters of the nest. I don't know why exactly, but they collect a little bit of everything. They collect many forms of vegetation, including sticks and cones. They collect scats, and this is where you get into the mammal remains--from carnivores, raptor pellets, bones, hair from carcasses, and so on. They collect tinfoil and anything that wasn't covered up and nailed down. They collect string I've put around the pit to identify the levels of excavation. They chewed on all my little canvas storage bags.

YS Any theories on why they do it?

EB No one is really sure. I think all these little things they do are geared toward protection of their nest. Having talked with packrat researchers, my guess is that when they take these scats and pellets they're collecting smells. What limits the distribution of most small mammals is the vegetation they need, but what limits pack rats isn't so much vegetation type as suitable nesting site. You have to look in the right spots for them, and where you find them doesn't seem to have much to do with the vegetation nearby. It has to do with the quality of their little cave and being near a cliff or a relatively inaccessible spot. It's their nesting sites that matter most to them.

YS So when they collect stuff, they're taking away things that they identify as some competitor's attempt to take over that territory?

EB Maybe. They might also be collecting scents so that if a predator were to come into their cave it would leave because it smelled another predator. That's one guess. Obviously, they're getting food, too. They chew on the bigger bones that they collect, and I've heard them gnawing on antlers when I've been working in the cave. They clip vegetation and bring willows in.

YS How big an object can they haul? They're not going to bring in an elk legbone.

EB No, but they can bring in a coyote legbone.

YS Does that introduce a bias against the biggest animals making it into the cave sample?

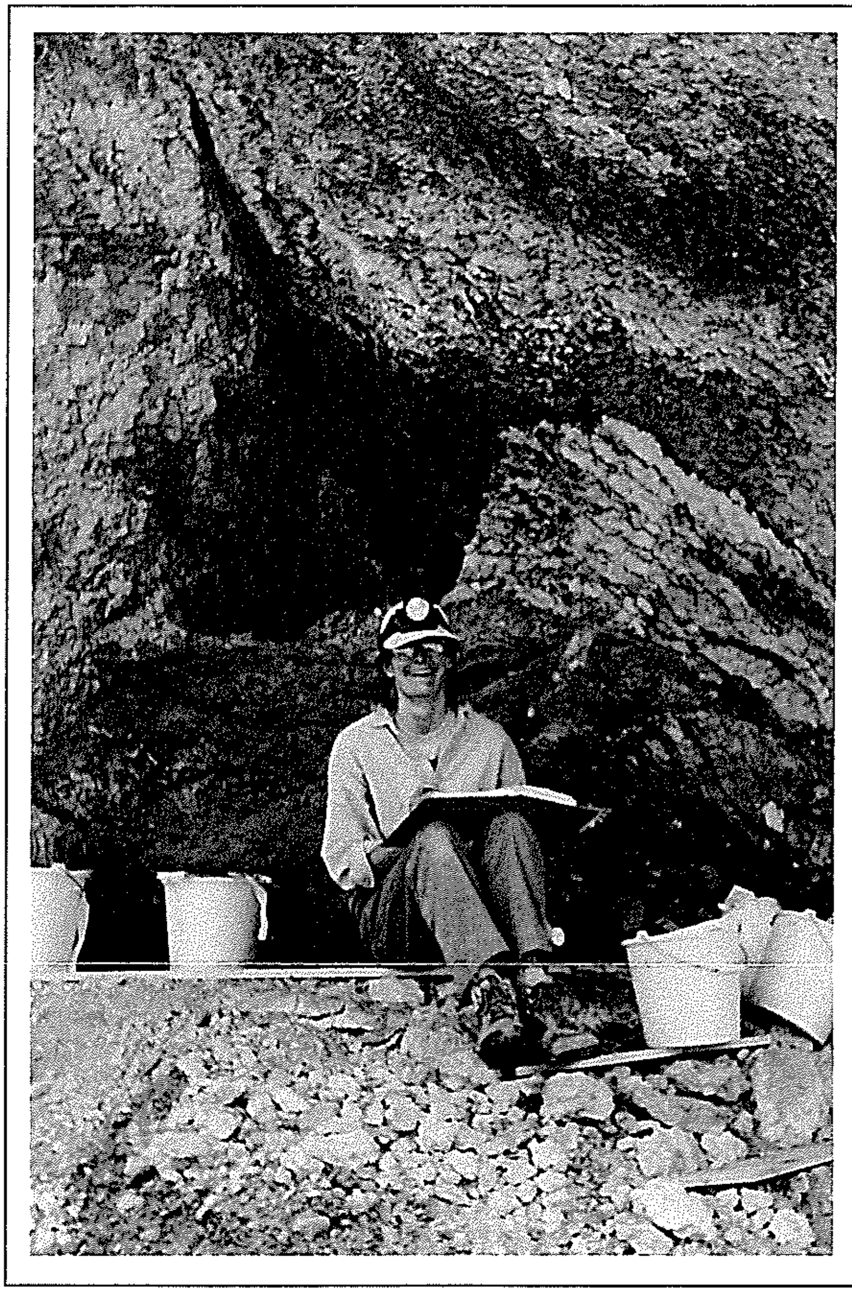
EB Yes, but Lamar Cave has been a carnivore den too, so the carnivores themselves will bring in big leg bones. But even at that, preservation in Lamar Cave has been against the survival of really big bones. One reason is that the big bones last longer as exposed objects. They're harder to cover up. If a coyote wandered into the cave and saw a fifty-year old piece of a femur sticking up through all this duff and organic stuff, he could pick it up and haul it out. A tiny mouse femur, on the other hand, is going to get buried with the first batch of vegetation that is laid on top of it. Plus, the packrats and the carnivores gnaw on the big bones and break them up. And so in Lamar Cave there are lot of big bones, but they're in little pieces.

YS You're mostly working with skulls?

EB Teeth. With the larger animals, I identify every single thing I can, because how often do you see a coyote dragging an elk's skull? That's not a part of the elk's body that most carnivores like to drag around, and so teeth of ungulates are not as easily deposited, although there are certainly teeth from large mammals in the cave, including elk, bison, deer, and sheep. We also have a lot of ungulate feet bones and leg bones. I can identify maybe one in twenty of the large mammal bone fragments, maybe even less than that. We count all these shards, and we know they come from large animals, anything from a coyote to a bison, and we often don't know which one. There may be ways to figure that out. There may be some way of looking at the DNA. The stuff in Lamar Cave is so young it's not fossilized.

YS Of course what has gotten a lot of attention in your findings have been the controversial animals, especially elk and wolves. There has been a "common knowledge" perspective for many years that elk and wolves weren't native to Yellowstone, and your study shows otherwise. But that isn't the primary focus for your study. Can you describe your focus?

EB First I'll tell you the reason why elk and wolves aren't my focus. There was no scientific reason for questioning whether or not elk and wolves were present here prehistorically. It's just obvious that it's not a scientifically valid question in terms of pure paleontology. It would never occur to a paleontologist that elk weren't here. Elk are doing fine here now, and there's been no major change that would suggest that suddenly this has become an optimal place for them. When you start looking at extinctions or exclusions of these big mammals, you have to go back 14,000 years to look at a time period that is really different from today, when you might add new large members of fauna



Opposite: the distribution of prairie vole remains in Lamar Cave reveal climate changes over the past 1,500 years. Above: Elizabeth Barnosky at her Soda Butte site.

to the mammalian community, or subtract them. So it's kind of intuitively sensible that they were present. Every time I've tried to incorporate elk or wolves into a presentation to a scientific audience that's not really even aware of the controversy here, they just think I'm wasting my breath. They don't doubt the animals were here.

For paleoecologists, there are much more interesting questions about Lamar Cave. It has an unusual time scale. It's not quite paleontology in some people's eyes because it's so young, and it's not quite biology in other people's eyes because it's so old. Yet it is both. It tells both disciplines a lot that other studies of other ages won't tell them. A paleontological site that is really young like this is fascinating because it tells us about more subtle changes than you could recognize in an older site that lasted over a longer period of time. It tells us a lot more about the perspective of the hundred-year changes that we're used to historically.

Packrats make it exciting too, because it's a short-term time scale, and the packrats still live in there. They run over my back when I'm excavating. They steal my things. I just love that, that they're still there, collecting. When I go back on Monday and look at this new pit, it's going to be covered with vegetation. You can still see it happening. It's just fascinating. It's not like something long dead, an animal that you have to imagine what it looked like and how it moved.

YS You mean like studying dinosaurs.

EB Right. That's a different area of fascination. Lamar Cave shows us a process that is still going on. It's really easy for me to imagine 2,000 years.

Analysis of paleontological evidence from a site requires sifting hundreds of bucketloads of soil, layer by layer, through progressively finer screens in search of small fragments of teeth and bone. All material is then bagged and catalogued for later examination.

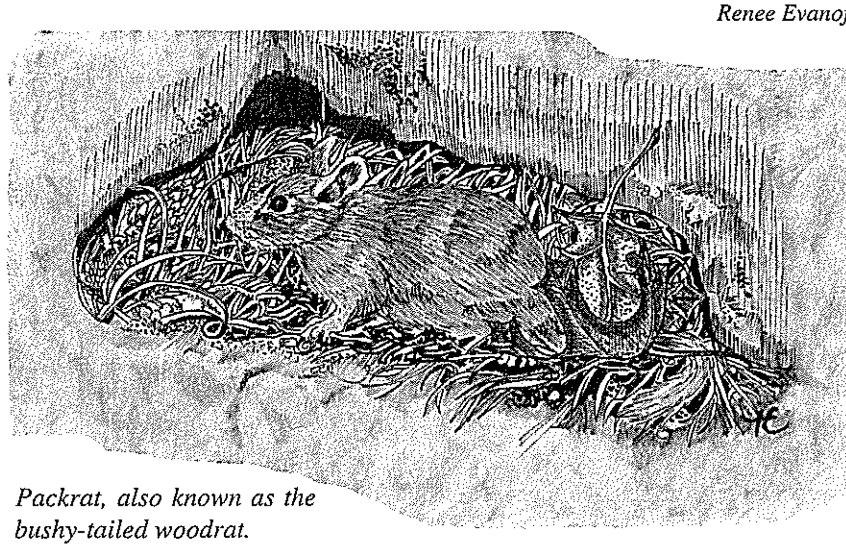
After the winter of 1988-1989, there were two winter-killed elk carcasses within a hundred meters of the cave. That summer, two packrat nests in Lamar Cave were made out of elk hair. You can watch the carcasses fade, you can watch the skeletons start to stand out, and you can watch the bones accumulate in the cave. You can see it all still happening.

YS Half the fun of your "detective work" in sorting out what has gone on around Lamar Cave the past couple thousand years must be in trying to sort out how the material got into the cave. Tell me about taphonomic bias.

EB This is a big question for paleontologists. How do you do a valid census of what lives in an area today? There are so many biases in small-mammal trapping. Some small mammals love the trap, some of them are trap shy. Some of them are only trapped at certain times. Some are nocturnal, some are diurnal. How do you capture everything that uses this little system? How long do you have to stand there to watch a grizzly bear go by? I think that Lamar Cave, with its packrats and carnivores gathering bones, does a better job of collecting a representative sample than we can. If you're out there and you're in abundance, you're going to get eaten. And if you get eaten around Lamar Cave, you're going to get put into Lamar Cave.

Taphonomy is the study of what happens to an animal after it dies until it's uncovered by someone, so the taphonomic bias is really important. At Lamar Cave, we're lucky because there are not a lot of things that happened to the remains after the animal died. Maybe it was preyed upon, or maybe it just died of starvation or freezing or whatever, then the bones were brought in to the cave by a packrat or a coyote or a wolf. Then the only thing that happened to it was that the packrats gnawed on it or a

Renee Evanoff



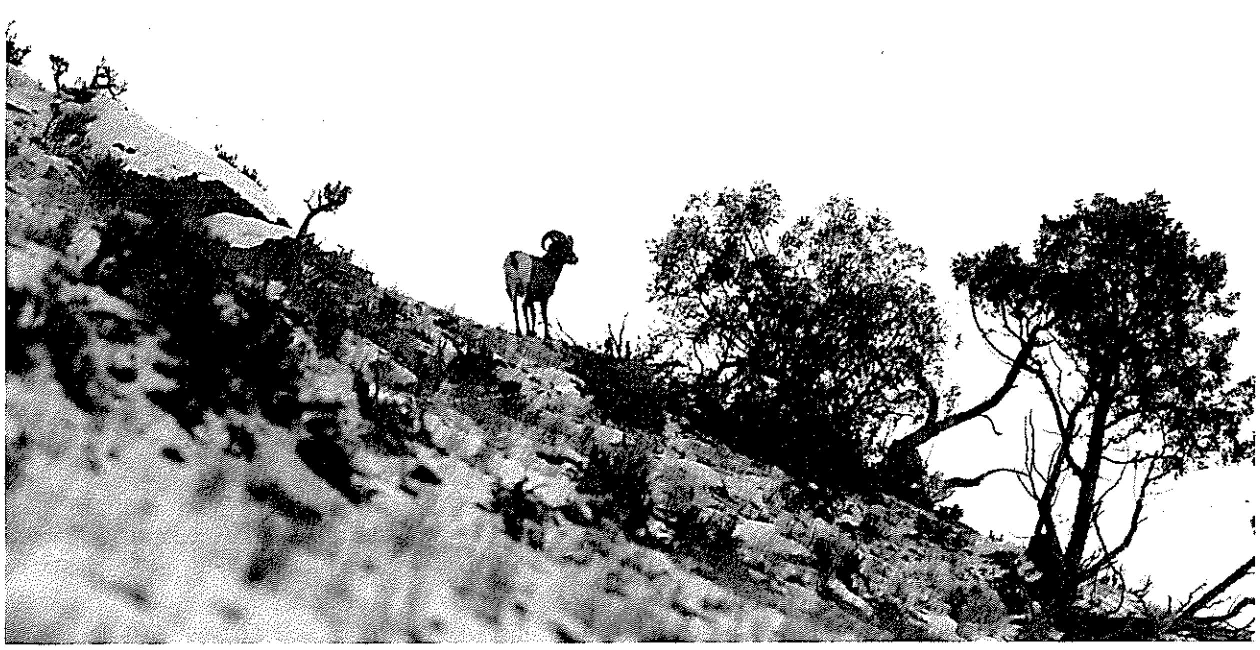
Packrat, also known as the bushy-tailed woodrat.

coyote broke it up or chewed on it. Maybe a fire came in and burnt it. Then it got buried by the periodic layering of sediments on the cave floor, and nothing else happened to it. So there's not a lot of disturbance, what is called bioturbation in this case, once it's finally buried in Lamar Cave.

But taphonomic bias is complex. Let's say that packrats range 100 meters from their nest. Does that mean that all these things that we find in the cave were collected within 100 meters? No. How far are coyotes and hawks and owls going to range to get the food that will make up their scats? Raptors can range pretty far. They produce pellets about every 24 hours, and so the pellets reflect where they've gone in a day.

My conclusion in my thesis was that practically everything I find in the cave came from within something like five miles of it. Three miles is about the daily home range size of a coyote, you know, kind of zigzagging and walking all around. Certainly raptors can fly great straight-line distances, but in watching the raptors out in the Lamar Valley, which is so big and wide, I saw that they tend to swoop down and capture something and then perch. Ravens and some of the hawks will sit on those big glacial boulders and isolated Douglas-firs.

I don't really know how far they all go, but there aren't extraneous animals



represented in Lamar Cave material to suggest that these bones are coming from any great distance like 50 miles away.

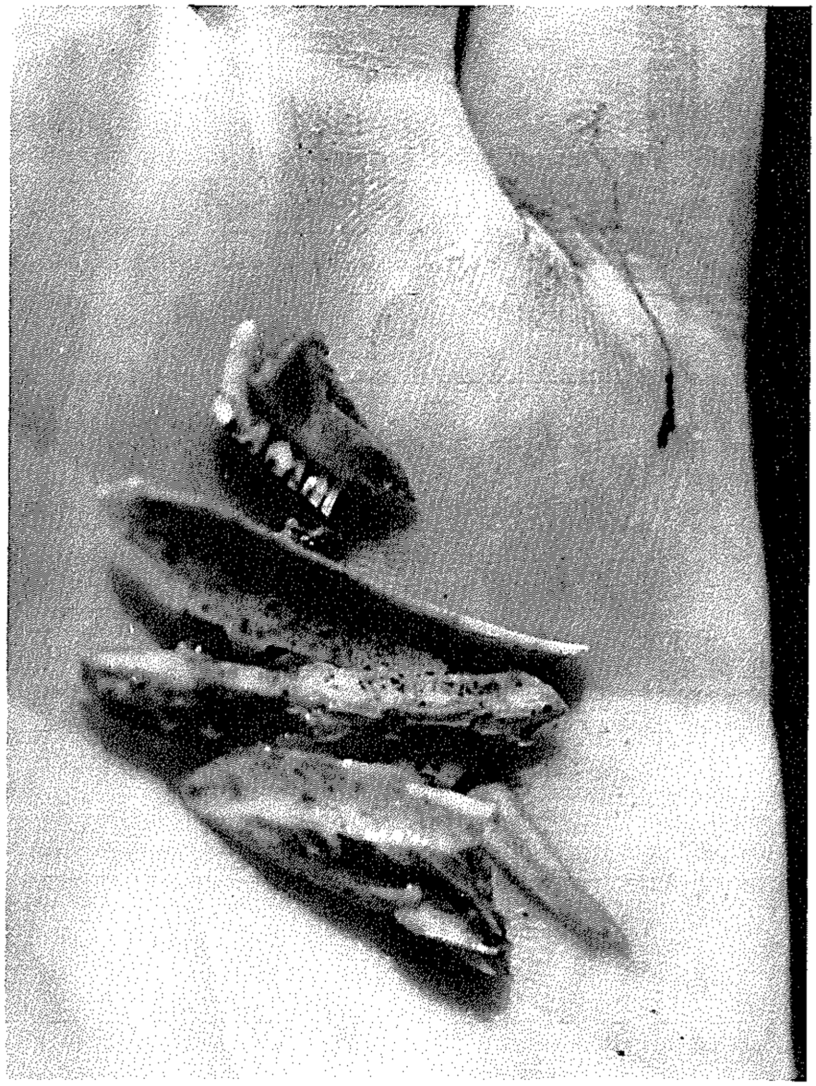
YS So perhaps the big question is, how much paleoecology can tell us? How does it radiate out from the bones you find to a portrait of what Yellowstone was like? Yellowstone is currently hosting several paleontological projects, including Cathy Whitlock's (*University of Oregon--Ed.*) studies of the pollen record in lakes and Grant Meyer's (*University of New Mexico*) dating of the fire record in alluvial deposits. It appears that you and your scientific colleagues are writing a whole new prehistoric biography of the region.

EB One thing you have to remember when you look at the records of the past is that they don't answer your questions exactly the way you want them answered. For example, the small mammals indirectly answer questions about the climate because there are direct effects of climate on animals. Usually, something like climate affects the vegetation first, and then the effect appears in the animals. But the process of understanding what happened by analyzing animal remains is still very interpretive.

For example, in the remains in Lamar Cave, there is a time period that appears to have been effectively drier, but I can't say for sure that it didn't rain just as much then. Maybe the amount of rain was the same but the average temperature was higher so that the moisture got used up faster, giving the effect of it being drier.

In some cases there is no way to answer questions like that with just the mammal evidence. But when you combine different paleo studies, you come closer to being able to answer those questions better. Interdisciplinary studies approach similar questions but from different angles.

Grant is finding periods of change that relate exactly to at least two time periods at Lamar Cave, one being the effectively drier period, and one the effectively wetter period. All this evidence makes you realize how broad-ranging the effects of a climatic change may be. Even if it's significant enough so that there's just a little more grass out there, what does that mean for the ecosystem? That's what Cathy's pollen studies can get at.



A palmful of paleontological clues, small bones and fragments (including an unidentified rodent jaw with a few teeth), freshly screened from the Lamar Cave site in northern Yellowstone.

YS The public conception of how changes happen is perhaps subconsciously based on their own life span. To most people, their life span meets their definition of a long time. But the hard lesson here in Yellowstone is that European Americans have only been active here for less than two centuries, and we've only got written records for a little more than a century, and that's not enough to tell us much about how these systems work. It just seems like that's hard for people to grasp.

EB Having a longer-term perspective of the past is really essential. When I hear someone say that the winters were a lot harsher when their grandparents were alive, and they had a lot more snow, or even if they say that things have changed a lot in the past ten years, it makes me realize that we don't have any idea where we're going. People are always trying to find some kind of order in the world so that they feel confident about the future. My confidence comes from just seeing what happened in the past.

YS So, what can the small mammals at your two sites tell you about change in the past?

EB I used the small mammal bones to look at how the relative abundance of these small mammals changed. In the Lamar Cave, it's so interesting because it's so easy to see, and because it relates so directly to how the animals live.

The ground squirrels, the ones that make the kamikaze dashes across the road in front of our cars, prefer to live in grasslands, and they like to be able to see. The reason they like to be able to see is that their social organization is such that that's how they protect themselves. They have a watchdog who is always whistling at you when you come too close; they depend on that social organization to protect their community. They burrow underground to escape from predators.

Voles, on the other hand, don't live in those tightly knit social communities. They need dense grasslands because they build grass-lined runways that hide them from predators. So if you suddenly put voles in very open grasslands, they're exposed and they run all over looking for cover because that's how they protect themselves. They live above ground and they don't have burrows like the ground squirrels do.

And so, even without looking at what these two species eat, just looking at their habitat preferences based on protecting themselves from predation, it's clear they thrive best in different microhabitats. The bones in Lamar Cave tell us that 1,000 years ago there were a lot more ground squirrels relative to the vole, and 1,500 years ago voles were more common than ground squirrels. Based on what we know about the habitat preferences of the two species, I concluded that 1,500 years ago it was wetter and 1,000 years ago it was drier.

There are still other questions, though; I'd like to understand a little bit more about how specific the various small mammals are to the habitat. Some of them aren't at all. Deer mice don't care where they are.

YS Is your new site aimed at helping you do that?

EB It is. My new site is in a different macrohabitat, in a forest. That's going to tell me about the big scale, of why are they different or if they're different. And so far I think they certainly are. But then within those two sites, small-mammal grids incorporate lots of different microhabitats. Both Lamar Cave and the new Soda Butte site have small mammal trapping studies going on.

YS The effect of those studies will be to give you a current check on how things are going for the small mammals, right?

EB Yes, there are many small habitats nearby, and so there are different scales in the study of this site from the Lamar Cave site.

This brought up some interesting questions. Is the Soda Butte site going to give us a different set of animals, that is a different assortment, in the forest around it than in the sagebrush-grasslands around Lamar Cave, several miles away? It's an important test of the precision of the study of paleoecology in Yellowstone.

YS Well? How does it look so far?

EB From the first go-round, the two sites have very different percentages of animals. We hardly had any rabbits or hares at Lamar Cave, but virtually every level at Soda Butte has rabbits and hares and pikas. It looks like the remains in the cave really are representing the areas and habitats nearby.

In paleontology it's easy to assume that what you find in a site is what was common in the region around it. But here in Yellowstone we have two sites less than 20 miles apart, probably about the same age. And yet they tell us very different things about what animals lived here. The sites really do tell you what was in the site's locality, rather than in the larger region.

The findings at Lamar Cave have been reported in Elizabeth Hadly's M.S. thesis, "Late Holocene Mammalian Fauna of Lamar Cave and its Implications for Ecosystem Dynamics in Yellowstone National Park, Wyoming," Northern Arizona University, 1990.

Book Review

Yellowstone Vegetation: Consequences of Environment and History in a Natural Setting. Don G. Despain.
Roberts Rinehart Publishers, Boulder, Colorado, 1990. xiii+239 pages; $14.95 (paper)

Yellowstone, the earth's first national park, occupies a central position in the Rocky Mountains of North America and is a favorite destination for tourists and scientists with special interests in natural history. *Yellowstone Vegetation* summarizes information on the ecology of plant communities in the area. Two chapters are rather detailed for amateurs, but the other six will be appreciated by a wide spectrum of park visitors.

After a brief introduction to the climate, geology, and land-use history of Yellowstone National Park (YNP), and a section on definitions, there is a long chapter (43% of the text) that describes 31 forest habitat types and 12 shrubland and grassland habitat types — some in more detail than others. Descriptions include two photographs, a small distribution map, the names of common plant species, elevational distribution, disturbance and successional characteristics, soils, and occasionally, insights on plant/animal interactions. An appendix provides a key for habitat type identification.

The details of distinguishing habitat types are of interest primarily to ecologists conducting research in the area, but the author used this information to calculate some statistics of interest to many. For example, 80 percent of YNP is forested, and of the forests, 60 percent would have subalpine fir as the characteristic climax tree. The remainder of the Park would be characterized, at the end of successional development, by either Douglas fir, whitebark pine, lodgepole pine, Engelmann spruce, or aspen. The most common grassland and shrubland habitat types are Idaho fescue/bearded wheatgrass, tufted hairgrass/sedge, big sagebrush/Idaho fescue, and silver sagebrush/Idaho fescue.

Because of lodgepole pine's current abundance, and the publicity it received in 1988, some will be puzzled by the absence of this species from the habitat type map (printed in color as the frontispiece). This anomaly is due to the author's conclusion that lodgepole pine is rarely a climax species (i.e., self-perpetuating without major disturbances such as fire). Habitat types are classified according to the perceived climax species, not necessarily the species that dominate the forest at the present time. Research by Despain and others suggests that lodgepole pine can indeed be the climax tree in drier environments, but apparently this is rare in Yellowstone .

The classification of park forests as they exist today was done using Despain's "cover type" concept. Each cover type is comprised of the vegetation that develops within a certain time period after a stand-replacing fire, the major disturbance that initiates secondary succession. For example, Despain's LP0 cover type is for lodgepole pine forests that have developed in an area burned within the last 40 years, and the LP1 cover type is for lodgepole forests that were initiated more than 40 but less than 150 years ago. The text briefly describes 15 forest cover types, and a small color map (inside back cover) attempts to show the distribution of 40 cover types. Unfortunately, the map is too small for this level of detail and the legend is confusing. This, and the repetition of one paragraph (bottom of page 82 and top of page 94) after an 11-page interruption in the text, are the major detractions from an otherwise well-edited volume.

One of the more interesting sections in the chapter on habitat types describes the ecological characteristics of aspen. Despain notes that aspen groves are infrequent, usually found in the northern part of the Park, and that they rarely cover more than 10 acres. Root sprouting is the most common form of reproduction, but seedlings are observed from time to time following fires and other disturbances, and when climatic conditions are favorable for their establishment. Despain maintains that aspen is very tolerant to browsing, persisting in some areas as small sprouts, and that some clones could be very old. Discussions of "juvenility" (pages 97-101) and chemical defenses to herbivory should have been supported with experimental evidence, from the literature or otherwise, but the author could be right in suggesting that the same aspen clones browsed by deer and elk today may have been fed upon by mammoths and camels.

The description of habitat types is followed by a four-page chapter on the plant communities of geyser basins (thermal areas). Data are presented showing how the vegetation changes as substrate temperature increases. Yellowstone's only known endemic plant, Ross' bentgrass (an annual), is found in this unique environment—warmed as much by the earth's molten interior as by the sun.

I predict that most readers will enjoy the second half of *Yellowstone Vegetation* more than they enjoy the first. In a section on the origin and distribution of vegetation, the geologic history and paleoecology of Yellowstone are reviewed. It is hard to imagine palms, avocados, and mangroves in Yellowstone 50 million years ago, just as it is difficult to believe that maples, oaks, and hickories were common 30 million years ago. However, the fossil evidence leaves no doubt about the climatic changes that have occurred. The importance of volcanic eruptions is discussed, but unfortunately the 27 layers of buried forest at Specimen Ridge are not described.

The chapter on paleoecology is followed by a detailed review of the Park's current physical environment. This chapter presents more data than any of the others, and includes climate diagrams for 13 weather stations in addition to, for example, a graph showing the relationship between snowcover and elevation and a table showing temperature changes with elevation during each month (lapse rates). The chapter ends with an analysis that suggests correlations between various vegetation types and soil characteristics. In general, lodgepole pine and some subalpine fir habitat types are found on the less fertile, coarser soils derived from rhyolite; whereas most meadows, sagebrush shrublands, and the mesic subalpine fir and whitebark pine habitat types are found on the more fertile, finer-textured soils derived from andesite.

Chapter six identifies the physiographic regions found within the Park, namely, the Gallatin Range, Absaroka Range, Central Plateaus, Southwest Plateaus, and the Yellowstone-Lamar River Valleys. A map illustrates the location of these "geovegetation provinces" and the text describes some of the unique characteristics of each. Also, there is a table that gives the percentage of each province covered by different habitat types and, interestingly, the percentage of each of the Park's habitat types found within the province.

At the heart of vegetation science is the analysis of disturbances and succession. In chapter 7 Despain identifies fire, insects, disease, wind, avalanches, water table changes, and changes in geothermal outputs as being the major disturbances. Fire, insects, and wind are discussed. The chapter presents a nice overview of fire ecology in coniferous forests, but the 1988 fires are not described in much detail. There is no map showing the extent of the 1988 fires, which is odd considering that there are 16 pages of maps (one per page) illustrating the spread of the mountain pine beetle from 1970 to 1985, all of which are simple enough to have been shown on one or two pages. Publication deadlines may have prevented the inclusion of additional data from 1988. Data on the Park's experience with fire from 1972 to 1988 (mostly to 1986) are included, and there are brief discussions of the effect of fire on fish, wildlife, and understory plants. The history of western spruce budworm control efforts is reviewed along with the effects of insects and wind on flammability and succession. The last chapter describes briefly, in five pages, how information on vegetation is useful for analyzing the habitat of rare species (the grizzly bear in particular), assessing potential fire behavior, and restoring lands disturbed by construction.

Overall, some readers will be disappointed by the lack of data on plant species composition, the small maps, little or no detail on methods, and very little integration of pertinent literature (for example, papers on the 1988 fires that appeared in *BioScience*, November 1989, were not cited). Also, most photographs have very sketchy captions that do not give locations or the names of the plants illustrated. The inclusion of repeat photographs would have been helpful; they are available and serve well to document vegetation changes. On the other hand, *Yellowstone Vegetation* summarizes a large amount of ecological information, much of it derived from the author's extensive experience. Details on the physiographic regions, climate, and habitat types of the Park are now readily available, as are interesting observations on, for example, the role of pine squirrels and meadows in providing food for grizzly bears, the vegetation differences caused by different kinds of volcanic rocks, and the author's view on the effects of large herbivores on aspen. This synthesis surely will elevate the ability of scientists and the general public for understanding and appreciating the plant life of Yellowstone—the primary goal of the author.

Dennis H. Knight
Department of Botany
University of Wyoming

News and Notes

"A new level of sophistication"

Biennial scientific conference series begins well

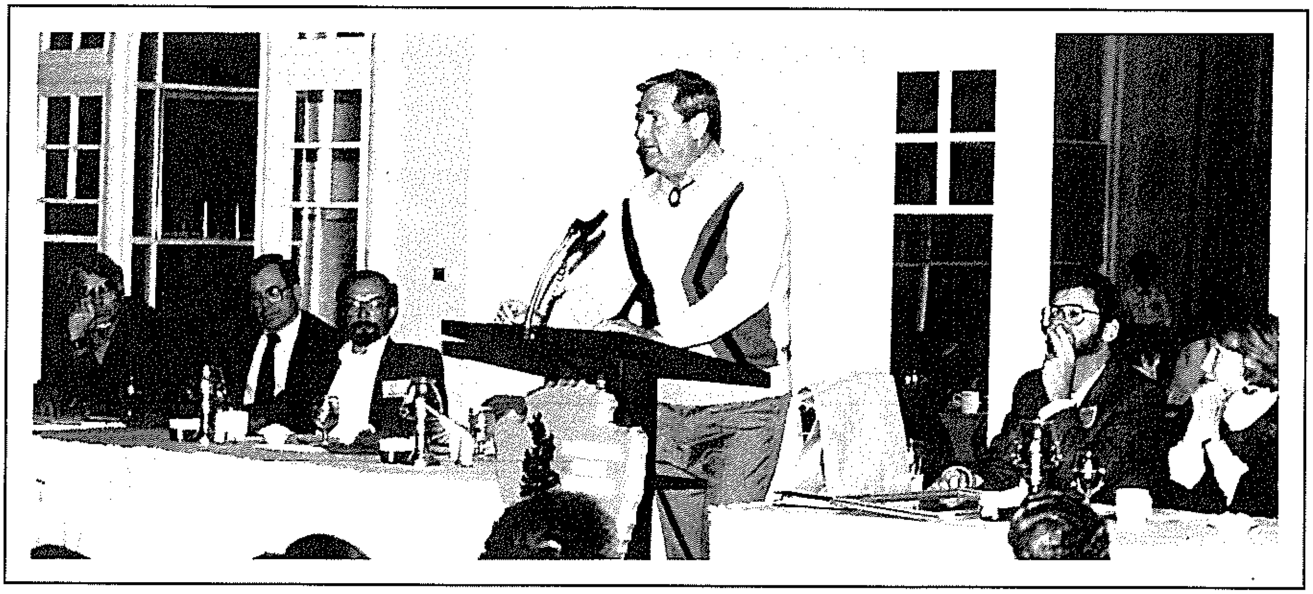
The First Biennial Scientific Conference on the Greater Yellowstone Ecosystem, entitled "Plants and Their Environments," was held at Mammoth Hot Springs, September 15-17, 1991. Attendance at the sessions varied from about 125 to 175, with 164 registered attendees. Though a variety of topics were considered, the foremost area of focus was the park's Northern Range, which has been the subject of many new studies in the past six years.

The conference was co-sponsored by the Ecological Society of America, Society for Conservation Biology, Society for Range Management, Wildlife Society, Yellowstone Association, U.S. Fish & Wildlife Service, U.S. Forest Service, Montana State University-University of Wyoming-Yellowstone National Park Cooperative Park Studies Unit, and National Park Service (host agency).

The conference featured 34 papers and 18 posters, and the proceedings will be published in the National Park Service Technical Report Series. When the proceedings is completed and available, *Yellowstone Science* will publish a review that provides details on these new research projects.

Besides the array of important new scientific papers, three keynote speakers provided broader perspectives on the kinds of research and resource issues facing national parks in general and Yellowstone in particular. Dr. Dwight Billings of Duke University opened the conference with a presentation on "the effects of global and regional environmental change on mountain ecosystems," portraying the consistencies of change that occur in apparently different settings, and pointing out some of the dramatic change that may occur in many life communities due to global climate change.

The conference banquet on Monday evening was highlighted by the first A. Starker Leopold Lecture, honoring the career achievements of the late A.



Yellowstone Superintendent Robert Barbee welcomes attendees to the International Luncheon. From left to right: Don Despain (NPS), Dennis Knight (U. of Wy.), Samuel McNaughton (Syracuse U.), Bob Barbee, John Varley (NPS), Anita Varley (NPS).

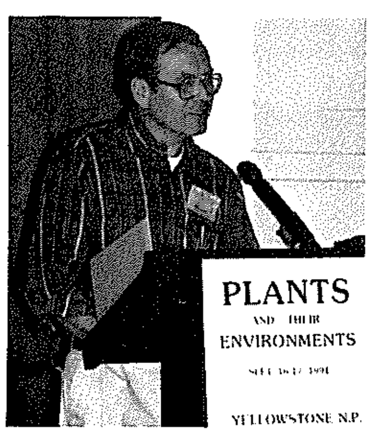
Starker Leopold (1913-1983), a pioneer in modern park ecology and management.

The lecture was delivered by Dr. Norman Christensen, also of Duke University. Norm's paper, "Plants in dynamic ecosystems: Is wilderness management an oxymoron?" addressed the ecological complexities of managing large natural areas that are constantly changing, just as our understanding of their functional processes continually changes. While acknowledging that "we truly are tinkerers. Our knowledge is woefully imperfect...," Norm asserted that "ignorance will not provide a reprieve from managing," and that through continued research, and through viewing management plans as "working hypotheses" that can be tested over time, the challenges can be overcome.

The Superintendent's International Luncheon provided an opportunity for a global perspective. Dr. Samuel McNaughton of Syracuse University delivered the inaugural paper in this series, "Comparative ecology of Yellowstone and Serengeti Ecosystems," pointing out that the magnitude and intensity of grassland use by Yellowstone ungulates is no greater than grazer use of large African wildland systems. Sam's statement that Yellowstone's grasslands are not overgrazed made headlines in regional newspapers, because the condition of Yellowstone's Northern Range has been debated for decades.

Dr. Dennis Knight, University of Wyoming, provided a masterful concluding overview of the conference, summarizing the many presentations. Dennis, reflecting on the wealth of new information, said that, while "knowledge pertaining to the ecology of plants in Yellowstone National Park was advanced to a new level of sophistication," much remains to be done, including more work on geyser basin plant ecology, plants in aquatic ecosystems, and the interactions of micro-organisms and plants. Dennis emphasized the special research opportunities provided by the park as a landscape "relatively free from human influences," and concluded that "given the opportunity, scientists can help managers achieve the important but difficult goal of natural area preservation."

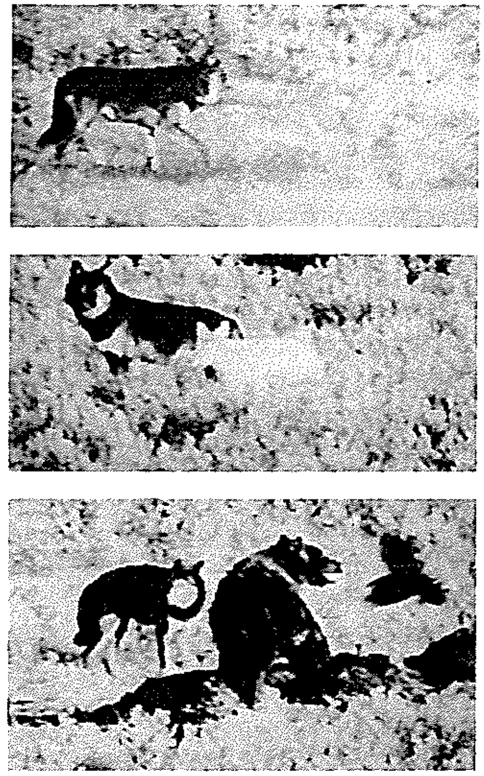
Dennis Knight, University of Wyoming, accepted the challenge of summarizing the conference.



The conference also featured field trips on wildlife, the Northern Range, aspen ecology, and fire, giving attendees a chance to get out and enjoy a glorious Yellowstone autumn. The large herd of elk that moves into the Mammoth area each fall was much in evidence; the bulls bugled day and night on the hotel lawns, with no apparent regard for the comfort of scientists who wanted to get some sleep after a long day.

John Varley, Yellowstone's Chief of Research, expressed the sentiments of conference organizers about the results of conference: "Launching this conference series was a major step for us, and the hallway talk suggests to me that we're off to a good start. There is so much interest in Yellowstone science and issues that a biennial series, with the active involvement of professional societies and other institutions, provides a perfect forum for the hundreds of researchers doing work here. We expect the second conference [*in 1993, on fire; see announcement on inside back cover of this issue. Ed.*] to be bigger and even better than this one."

News and Notes, continued



An important picture is not necessarily a technically fine photograph; our only still images of the possible wolf are these conversions of videotape made from 16 mm. movies. The top picture shows the animal alone (note the long legs), the middle shows it with a coyote passing in front of its hind quarters, and the bottom shows it close to a grizzly bear on a bison carcass. The indistinct black shapes near the animals are flying ravens. Courtesy of Busch Productions, Inc.

Was it a wolf?

On August 7 and 8, 1992, Ray Paunovich, a film producer from Bozeman, Montana, sighted and filmed a large wolf-like canid in Hayden Valley in central Yellowstone Park. Ray, who is currently producing a grizzly bear film for Busch Film productions, of Whitefish, Montana, has produced several NOVA nature films involving Yellowstone, and has extensive experience filming wolves.

The film is of special significance, not only for its exceptional quality (the first professional footage in any possible Yellowstone wolf sightings), but also for its contents. Ray filmed the animal interacting with grizzly bears, ravens, and a coyote, giving scientists the opportunity to study its size and behavior in relation to these other animals, as well as its color and other physical characteristics.

The animals were all feeding on two bison carcasses (apparently the result of bison bulls fighting during the rut); the footage shows one grizzly bear in control of the carcasses while the wolf-like animal approached the carcasses cautiously, grabbing an occasional chunk of meat to then eat at a distance. The coyote in the footage often stayed quite near the wolf-like animal, apparently scavenging on its leftovers.

The sighting received national media notice, including an article in *Newsweek* and short segments of the film shown on *NBC*, *ABC*, and *CNN*. Wolf researchers who watched the film concluded that the animal did not act like a recently escaped domestic wolf or hybrid; it displayed a familiarity with the other scavengers and its role in relation to them. All agreed, however, that unless the animal is captured and subjected to genetic studies, its true taxonomic character cannot be determined. As of late August, researchers were monitoring the area to determine if the animal was still there.

Wolves were almost completely eliminated from the Greater Yellowstone Ecosystem by the 1930s, though occasional sightings of possible or probable individual animals have occurred intermittently since then. The U.S. Fish and Wildlife Service is currently preparing an Environmental Impact Statement on wolf reintroduction to Yellowstone and central Idaho.

A Lake-bottom Geyser

An apparent first underwater geyser has been identified in Yellowstone Lake, near West Thumb Geyser Basin. Park Interpreter John Dahlheim first noticed surface disturbances about 50 yards offshore just south of the basin, and informed Val Klump, who has been conducting a variety of lake-bottom investigations using a small remotely operated vehicle (ROV) carrying a videocamera.

Val, from the University of Wisconsin-Milwaukee, Center for Great Lakes Studies, launched the ROV at the site and was able to locate the source of the flow in 15-20 feet (5-6 meters) of water, where, under a "canted ledge," there was at least a slight continuous flow of hot water and gas. Every 20-25 minutes, however, the flow increased, in what Val described as the first evidence of periodic geothermal activity (that is, geyser-like bursts of flow rather than steady flow) in the lake. The ROV has allowed Val to locate other possible sites of such activity in other parts of the lake, but the activity has never been observed.

During the "eruptions," the surface of the lake seemed to be slightly bulged, but the more noticeable effect was a smooth patch that "disturbs the wave field" in the area. Because of the small size of the channel under the ledge, the ROV was unable to measure the temperature of the water at the source. The highest temperature measured was about 86 °F(30°C) (the lake water there is about 59°F, or 15°C), but the water was probably considerably warmer at the source.

Val also provided an intriguing biological observation. It is the first underwater geothermal site he has found in the lake that seemed to attract, rather displace, trout. One large cutthroat trout, as Val put it, "may be making a living by hanging around there." It appeared that the fish moved into the upwelling of gas and water during the eruption. The eruption apparently churned up enough of the lake water to concentrate local invertebrates in a way that the trout could use.

Irving Friedman honored for Yellowstone work

In May, Dr. Irving Friedman of the U.S. Geological Survey received the stewardship award of the Greater Yellowstone Coalition for his work in research and protection of Greater Yellowstone geothermal resources.

Irving, who has an international reputation in the field of stable isotopes as applied to hydrology and geology, has been actively involved as a researcher in Yellowstone for many years. The Coalition gave him the award because he has been an outspoken advocate of stronger and more protective geothermal legislation, repeatedly testifying before Congress and in other ways applying his expertise and voice to the dialogues over the future fate of the region's geological wonders.

Bear Number One 1964-1992

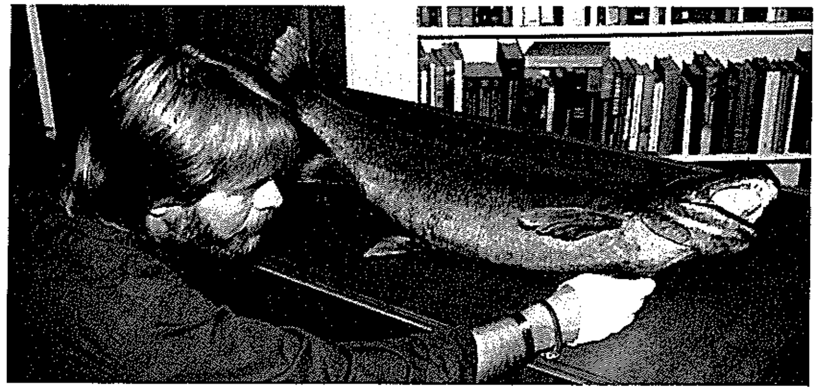
Grizzly bear #1, the first grizzly bear marked by the Interagency Grizzly Bear Study Team (IGBST), died in April, shortly after emerging from his den. At 28, he was one of the oldest documented grizzly bears in the more than 30 years of grizzly bear research in the Greater Yellowstone Ecosystem. He apparently died of natural causes; the signal on his collar switched to the mortality mode on April 4. When he was located by researchers his remains were too decomposed for study, but it appeared that he had been fed on by another bear.

Number One was first trapped in Wyoming in 1975, on Lodgepole Creek in Wyoming, southeast of Cooke City. His weight was estimated as 310-330 lbs.. He was recaptured seven times, the last being on September 23, 1991, on Siggins Fork in Bridger-Teton National Forest; he then weighed 563. Though he was radio collared several times, transmitter failures resulted in the accumulation of only two years of complete data on his movements. His estimated home range for that period was about 820 square miles, though his lifetime range was no doubt larger than that.

Bear Number One bridged major eras in Yellowstone history. Born during the peak of human food availability to bears, when many grizzly bears fed at garbage dumps in and near the park, he survived the controversial transition years of the late 1960s and early 1970s, when the grizzly bear population was "weaned" from those food sources, and when management removals of grizzly bears were at a historical high. Significant changes in natural foods occurred after the dump closures, including increases in trout and ungulate populations, so Number One spent most of his long life adjusting to new conditions.

Though Number One was repeatedly trapped, he was not an especially visible bear, and once went for five years (1983-1988) without being officially observed, trapped, or otherwise dealt with. He was the first of more than 200 bears to be captured and studied by the IGBST, whose study of the Yellowstone grizzly bear population is now in its twentieth year.

Big Fish Comes Home



Yellowstone Park Historian Tom Tankersley examines Dr. Silvernail's 1935 trophy lake trout shortly after its return to the park.

On July 9, 1935, Dr. C.H. Silvernail, a dentist from Bridgeport, Nebraska, caught a 37-pound (38-inch) lake trout from Heart Lake in southern Yellowstone Park. Dr. Silvernail hooked the fish at a depth of about 100 feet, and played it for 45 minutes. It was, in the words of Ranger Robert Beal, who filed a special incident report on the event, "one of the largest Mackinaw trout ever taken in Yellowstone Park." The fish won second place in that year's *Field & Stream* contest. Dr. Silvernail had the fish mounted, and it became a local attraction and conversation piece for many years.

When Dr. Silvernail passed away recently, his daughter, Mardell Silvernail Smith (Mrs. Sterling P. Smith), expressed an interest in having the fish returned "to his original environment." With the help of Chief Ranger Palma Wilson and Superintendent Joann Kyral of Scotts Bluff National Monument, Nebraska, the fish was transported back to Yellowstone, where it now awaits restoration.

This specimen is much more than a special momento of Yellowstone history, and has value beyond its worth as the largest park trout of which there is official record. Prior to restoration, a small amount of material from the fish will be removed (from the back of the mount) for DNA analysis. That process may be revealing in several ways, including comparisons with Great Lakes lake trout DNA from the same period (the early plants of trout in Yellowstone have in some cases preserved "museum-grade" examples of strains of fish that elsewhere were long ago altered by fisheries activities). Analysis of the scales and other material may also yield information about growth rates of trout more than half a century ago, and chemical analysis might reveal levels of lake pollutants as well.

First announcement

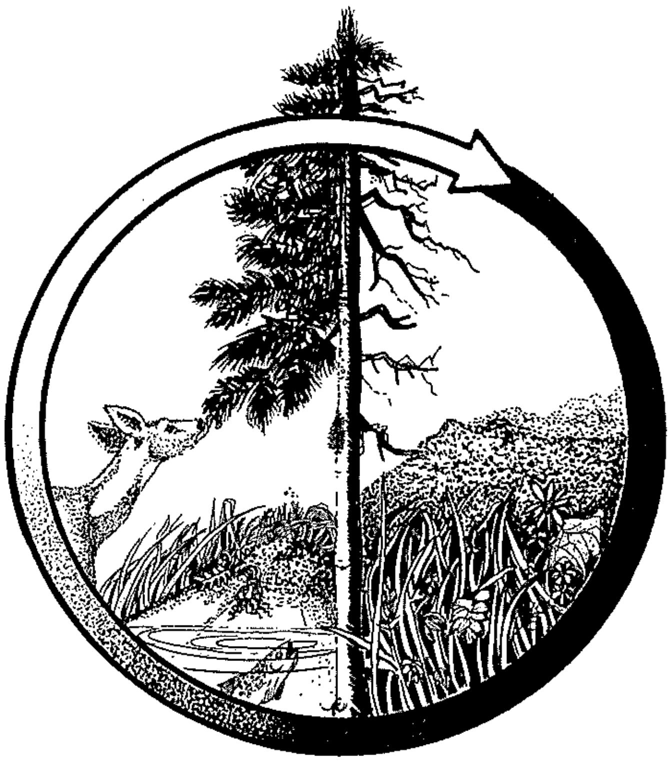
Fire in Greater Yellowstone

Second Biennial Scientific Conference on the Greater Yellowstone Ecosystem

September 1993

Yellowstone National Park

Wyoming



The Yellowstone fires of 1988 resulted in one of the most intensive research programs in the history of the world's national parks. As of 1991, there were no less than 78 fire-related research projects underway, from numerous studies of vegetation (trees, grasslands, and other plant communities), to studies of various animal species (including insects, grizzly bears, mountain lions, and coyotes) to studies of the park'sdiverse aquatic ecosystems. These studies will give us a rare glimpse at the consequences and complexities of one of Greater Yellowstone's most important ecological processes.

The fifth anniversary of the 1988 Yellowstone fires is a significant time in postfire research, and many projects will be advanced enough to permit important findings to be reported. The conference will therefore be a milestone in wildland fire research. Watch for details in future announcements, or contact the Division of Research, Post Office Box 168, Yellowstone National Park, WY 82190, to be placed on the mailing list. All currently permitted Yellowstone investigators will automatically receive notice of the conference.